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CRYSTALLOGRAPHY.—*The crystallography of morphine and certain of its derivatives.* EDGAR T. WHERRY and ELIAS YANOVSKY, Bureau of Chemistry.

Optical-crystallographic methods having proved to be of practical value in the identification of the cinchona alkaloids,[1] attention was directed by the writers to another group of alkaloids, namely, morphine and its derivatives, to ascertain if similar methods could be applied there. Commercial samples were purified (by the junior author) as described below, and crystallographic measurements were made to establish their identity with previously described material. On trying these substances by the immersion method under the polarizing microscope it was found that they dissolved so rapidly in every immersion liquid approaching them in refractive index that their identification by this method would be impracticable. It is probable that some of their salts, such as the hydrochlorides, being less readily soluble, would be better adapted for optical-crystallographic identification, and it is planned to prepare and study these compounds, although the withdrawal of the junior author from the Bureau of Chemistry has led to delay in carrying this out. The results of the crystallographic measurements of the alkaloids are, however, of considerable scientific interest, and this account of them has accordingly been prepared.

[1] Journ. Amer. Chem. Soc. 40: 1063. 1918.

MORPHINE MONOHYDRATE, $C_{17}H_{19}NO_3.H_2O$

Anhydrous morphine has apparently never been prepared in well-crystallized condition, but the monohydrate, which separates from all the usual solvents of this alkaloid, has been the subject of several crystallographic investigations. Brooke[2] described crystals showing a pinacoid, prism, and dome, his angle measurements, when transformed, yielding $\phi_{\text{prism}} = 63^\circ\ 40'$ and $\rho_{\text{dome}} = 42^\circ\ 20'$. Schabus[3] measured crystals with a pinacoid, a prism with $\phi = 63^\circ\ 27'$ and a dome over the pinacoid with $\rho = 24^\circ\ 54'$; he made the pinacoid and dome side- or

TABLE 1. ANGLE TABLE FOR MORPHINE MONOHYDRATE

RHOMBIC (BISPHENOIDAL); $a:b:c = 0.499:1:0.927$[a]

Number	letter	Symbols G'd't	Mill.	Description	Observed φ	Observed ρ	Calculated φ	Calculated ρ
1	*c*	0	001	Listed by Rammelsberg	.....	.....	.....	0°00′
2	*b*	0∞	010	Dominant form; cleavage direction	0°00′	90°00′	0°00′	90°00′
3	*m*	∞	110	The only prism form	63°30′	90°00′	63°29′	90°00′
4	*q*	0½	012	Observed and taken as the unit by Schabus	.....	.....	0°00′	24°52′
5	*r*	01	011	The best developed termination	0°00′	42°50′	0°00′	42°50′
6	***p***	1	111	Reported by Decharme	.....	.....	63°29′	64°17′

[a] The axial ratio given is the average of those obtained by the various investigators of this substance. It is stated to but three decimal places because of the wide variations which appear to exist. The angles of the crystals here measured showed a maximum variation of ±20′, and the probable error of the observed value is about 5′.

brachy-forms. Lang[4] established the optical orientation on crystals with what appear to have been the same forms, but he took the pinacoid and dome as front or macro-forms. Decharme,[5] without measuring any angles, observed a development of bisphenoidal faces on crystals of two different habits.

[2] Ann. Phil. (N. S. 6) **22**: 118. 1823; discussed by SCHABUS, *Best. Kryst.-gest. chem. Lab. erz. Prod.*, Vienna, 1855, p. 74, and by RAMMELSBERG, *Handb. Kryst.-phys. Chem.* II, 358. 1882.

[3] Loc. cit.; abstract in Jahresb. **1854**: 510, and in RAMMELSBERG, loc. cit.

[4] Sitzb. Akad. Wiss. Vienna **31**: 115. 1858.

[5] Ann. Chim. phys. (Ser. 3) **68**: 160. 1863.

The alkaloid liberated from a commercial sample of the hydrochloride was recrystallized from absolute methyl alcohol until its specific rotation remained the same in two consecutive crystallizations. The final value for a 1% solution in methyl alcohol was $[\alpha]_D^{20°} = -131.7°$. The usually recommended recrystallization from amyl alcohol was found to be less satisfactory.

The crystals finally obtained from methyl alcohol, which attained a diameter of about 1 mm., were measured on a Goldschmidt two-circle goniometer, with the results presented in table 1. The orientation adopted is that of Schabus, but the steeper dome is taken as the unit form, giving a value different from his for axis *c*.

The essential agreement between the measurements of preceding authors and those here reported indicates that morphine normally crystallizes, as monohydrate, in a single form, there being no evidence of polymorphism.

Partial optical descriptions of this substance have been published by Lang,[6] by Kley[7] and by Wright[8] but there are considerable discrepancies among their results. On examining our material by the immersion method, using liquids made up chiefly of a petroleum oil, in which the alkaloid is but slightly soluble, the data of Lang and of Wright were confirmed for the most part, and Kley's value for one refractive index could be explained as a mean between the largest and smallest indices, while his axial angle must be 2 V. The data obtained were:

Refractive indices $[_D^{20°}]$ $\alpha = 1.580$, $\beta = 1.625$, $\gamma = 1.645$, $\gamma - \alpha = 0.065$, all ± 0.005. Index β is usually shown lengthwise of the rods, and one of the other, or intermediate, values, crosswise; the optic axial plane is perpendicular to the elongation of the crystals; axial angle 2E is very large, approximately 125°; sign — ; dispersion strong with $2E_r > 2E_v$.

CODEINE, MORPHINE METHYL ESTER, $C_{18}H_{21}NO_3$

This alkaloid crystallizes in both anhydrous and hydrous forms. The former was obtained from carbon disulfide solution and

[6] Loc. cit.

[7] Zeitschr. anal. Chem. 43: 164. 1904.

[8] Journ. Amer. Chem. Soc. 38: 1655. 1916.

described crystallographically by Arzruni.[9] The forms observed were front and side pinacoids, two prisms, front and side domes, and right and rarely left sphenoids, the important angles being, as transformed: $\phi_{110} = 47° 05'$ and $\rho_{101} = 28° 41'$, corresponding to $a:b:c = 0.930:1:0.509$.

It was found best to recrystallize this alkaloid from ethyl acetate until the melting point became constant at 153° (Grimaux[10]). Fine crystals 2 mm. in diameter were finally obtained, which were measured, with the results shown in table 2.

TABLE 2. ANGLE TABLE FOR CODEINE

RHOMBIC, BISPHENOIDAL; $a:b:c = 0.931:1:0.509$[a]

Number	letter	Symbols G'd't	Mill.	Description	Observed φ	Observed ρ	Calculated φ	Calculated ρ
1	*b*	0∞	010	Narrow; often absent	.....	.....	0°00′	90°00′
2	*a*	∞0	100	Prominent form	90°00′	90°00′	90°00′	90°00′
3	*m*	∞	110	One prism form	47°00′	90°00′	47°03′	90°00′
4	*n*	∞2	120	Another prism form	28°15′	90°00′	28°14′	90°00′
5	*q*	01	011	Small; often absent	.....	.....	0°00′	26°59′
6	*d*	10	101	Dominant terminal form	90°00′	28°40′	90°00′	28°40′
7	*p*	1	111	Well developed, sphenoidal, both + and −	47°00′	36°45′	47°03′	36°46′

[a] As with morphine the measurements vary ±20′, so axes are given to but three places.

The form above described, which we have found to separate also from absolute ether and methyl and ethyl alcohols, is evidently the same as that described by Arzruni.

The marked solubility shown by this alkaloid has permitted only rough measurements of the refractive indices as: $\alpha = 1.62$, $\beta = 1.63$, $\gamma = 1.65$, $\gamma - \alpha = 0.03$. The axial angle $2E$ is very large, about 125°; the sign +; and the dispersion strong, with $2E_r > 2E_v$. These agree with the data of Arzruni.

CODEINE MONOHYDRATE, $C_{18}H_{21}NO_3.H_2O$

At least six different authors have studied this form of codeine; and their results have been tabulated and discussed by Heydrich.[11] The forms which have been observed are the base, a prism with $\varphi = 45° 50'$ to $46° 15'$; two side domes with $\rho =$

[9] Zeitschr. Kryst. Min. 1: 302. 1877.

[10] Ann. chim. phys. (Ser. 5) 27: 274. 1882.

[11] Zeitschr. Kryst. Min. 48: 270. 1910.

22° 35′ to 22° 52′ for one, and 39° 12′ to 40° 02′ for the other; and a front dome with ρ = 40° 46′ to 41° 04′. The prism and the steeper side dome are taken as the unit forms. For the present study crystals were grown from water and from hydrous methyl alcohol, attaining a diameter of 2 mm. The results were:

TABLE 3. ANGLE TABLE FOR CODEINE MONOHYDRATE

RHOMBIC; PROBABLY BISPHENOIDAL; $a:b:c$ = 0.960:1:0.830[a]

Number	letter	Symbols G'd't	Mill.	Description	Observed φ	Observed ρ	Calculated φ	Calculated ρ
1	c	0	001	Narrow, often absent	.....	0°00′	.....	0°00′
2	m	∞	110	Dominant form	46°10′	90°00′	46°10′	90°00′
3	k	$0^1/_2$	012	One terminal form	0°00′	22°35′	0°00′	22°32′
4	q	01	011	Another terminal form	0°00′	39°40′	0°00′	39°42′
5	r	10	101	Observed by Heydrich	.....	.....	90°00′	40°51′

[a] The crystals were somewhat better in this case than in the two preceding ones, and the maximum variation was but ±10′, but previous results have varied so markedly that only three decimal places are used for the average axial ratios given.

The agreement between these results and the average of those of previous authors is close.

Codeine monohydrate has been described optically by Kley,[12] by Heydrich[13] and by Wright.[14] The measurements by the first and last of these authors are admittedly only approximate, because of the solubility, but Heydrich's measurements were made by the prism method, and are more accurate. The immersion method gave on our material roughly α = 1.54, β = 1.64, and γ = 1.69, $\gamma - \alpha$ = 0.15; axial angle 2E very large, around 130°; sign —; and dispersion distinct, with $2E_r < 2E_v$.

CODETHYLINE, MORPHINE ETHYL ESTER, MONOHYDRATE

$C_{19}H_{23}NO_3.H_2O$

The ethyl ester of morphine, the hydrochloride of which is known commercially as dionin, has apparently never been measured crystallographically.

[12] Loc. cit.
[13] Loc. cit.
[14] Loc. cit.

Some commercial dionin was dissolved in water, and ammonium hydroxide added to precipitate the alkaloid. This was extracte d

TABLE 4. ANGLE TABLE FOR CODETHYLINE MONOHYDRATE

RHOMBIC, PROBABLY BISPHENOIDAL; $a:b:c = 1.454:1:0.789$[a]

Number, letter	Symbols G'd't	Mill.	Description	Observed φ	Observed ρ	Calculated φ	Calculated ρ
1 *b*	0∞	010	Narrow; cleavage direction	0°00′	90°00′	0°00′	90°00′
2 *n*	2∞	210	One prism form	54°00′	90°00′	53°59′	90°00′
3 *m*	∞	110	Another prism form	34°30′	90°00′	34°31′	90°00′
4 *k*	$0^1/_2$	012	Narrower dome	0°00′	21°30′	0°00′	21°32′
5 *q*	01	011	Dominant terminal form	0°00′	38°15′	0°00′	38°16′
6 *d*	10	101	Well developed	90°00′	28°30′	90°00′	28°29′

[a] The maximum variation of ±20−observed renders the axial ratios uncertain beyond the third decimal place.

by ether, and recrystallized from this solvent until the melting point became constant at 83°.

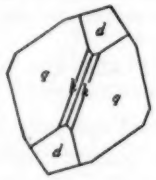
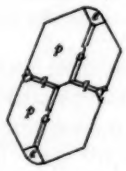
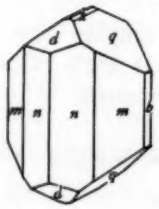


Fig. 1.—Codethyline





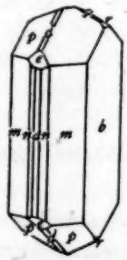


Fig. 2.—Heroine

The crystals obtained from ether containing a little water reached a diameter of 5 mm., and were measured, with the re-

sults presented in table 3 and in Fig. 1. The orientation adopted is that which brings out the relationship between this substance and the two previously described monohydrates.

The immersion method yielded the following approximate data for these crystals: Refractive indices $\alpha = 1.55$, $\beta = 1.58$, $\gamma = 1.65$, $\gamma - \alpha = 0.10$; axial angle very large, about 125°; sign +; dispersion distinct, with $2E_r > 2E_v$.

HEROINE, DIACETYL-MORPHINE, $C_{21}H_{23}NO_5 = C_{17}H_{17}NO(CH_3COO)_2$

The commercial alkaloid was recrystallized until a product with a constant melting point of 171–172° was obtained. (Various authors give from 169 to 173°.) It was found to crystallize well from ether, ethyl acetate, and methyl alcohol. No crystallographic description of this substance could be found in the literature, so four of the excellent crystals obtained from ethyl acetate were submitted to measurement, with the results presented in table 5, and Fig. 2.

TABLE 5. ANGLE TABLE FOR HEROINE

RHOMBIC, BISPHENOIDAL; $a:b:c = 0.8952:1:0.497$[a]

Number	letter	Symbols G'd't	Mill.	Description	Observed φ	Observed ρ	Calculated φ	Calculated ρ
1	*b*	0∞	010	Dominant form	0°00′	90°00′	0°00′	90°00′
2	*a*	∞0	100	Narrow, yet well marked	90°00′	90°00′	90°00′	90°00′
3	*n*	2∞	210	Narrow prism form	65°55′	90°00′	65°54′	90°00′
4	*m*	∞	110	Dominant prism	48°10′	90°00′	48°10′	90°00′
5	*q*	01	011	Narrow but definite	0°00′	26°30′	0°00′	26°28′
6	*r*	02	021	Very small	0°00′	45 ±	0°00′	44°53′
7	*d*	10	101	Narrow, yet well marked	90°00′	29°07′	90°00′	29°06′
8	*e*	20	201	Small but definite	90°00′	48 ±	90°00′	48°03′
9	*p*	1	111	Dominant terminal form; both + and − sphenoids	48°10′	36°45′	48°10′	36°45′

[a] The crystals of this alkaloid were more perfect than those of any of the others, and the maximum variation on angles was but ±5′, the probable error of any one measurement being ±1′. This permits statement of the axial ratios to the fourth place.

The crystals obtained from other solvents showed the more prominent of these forms, and the angles agreed within half a degree.

The optical properties obtained by the immersion method are as follows: Refractive indices: $\alpha = 1.56$, $\beta = 1.60$, $\gamma = 1.61$, $\gamma - \alpha = 0.05$; the maximum and minimum indices are usually

seen on the plate-like crystals; the optic axial plane being parallel to the surfaces of the plates, no interference figure is visible in most cases, but when flakes are broken across and tilted up, partial figures can be seen, the axial angle 2E being large, about 110°; sign —; and dispersion strong, with $2E_r > 2E_v$.

On comparing the axial ratios of these alkaloids, it is at once seen that there are certain relationships among them, and it seemed of interest to calculate and compare their topic axial ratios. For this purpose their specific gravities were determined approximately by suspension of clear crystals in mixtures of sassafras oil and small amounts of bromoform, a combination selected because it was found to attack the substances but slowly; and the gravity of the liquid in each case was then measured by a Westphal balance. The results are presented in table 6.

TABLE 6. TOPIC AXIAL RATIOS OF THE MORPHINE ALKALOIDS STUDIED

Name	Compound of morphine	Crystallographic axes a	c	Mol. wt. W
Morphine	..... + $1H_2O$	0.499	0.927	303.2
Codeine	methyl ester	0.931	0.509	299.2
Codeine	methyl ester + $1H_2O$	0.960	0.830	317.2
Codethyline	ethyl ester + $1H_2O$	1.454	0.789	331.2
Heroine	diacetyl deriv.	0.895	0.498	369.2

		Sp. gr. P	Sp. vol. V=W/P	Topic axes χ	ψ	ω
Morphine	..... + $1H_2O$	1.32	229.7	3.95	7.92	7.34
Codeine	methyl ester	1.32	226.7	7.28	7.82	3.98
Codeine	methyl ester + $1H_2O$	1.31	242.1	6.45	6.72	5.58
Codethyline	ethyl ester + $1H_2O$	1.29	256.7	8.83	6.07	4.79
Heroine	diacetyl deriv.	1.32	279.7	7.66	8.56	4.26

The topic axial relations exhibit certain interesting features, and permit of determining in which direction in the crystals substitutions or additions occur. Thus, comparing anhydrous codeine with its monohydrate, it is seen that the addition of the water takes place in the vertical direction, producing a 40 per cent increase in axis ω while χ and ψ both decrease about 15 per cent. Comparing the three monohydrates, of morphine and of its methyl and ethyl esters, it comes out with equal clearness that the CH_2 groups enter along the front-back axis, for the value of χ increases 50 per cent from morphine to its methyl ester, and 40 per cent more from the methyl to the

ethyl ester, the other two axes showing decreases of 15–20 per cent in each case. Comparison of the diacetyl derivative with morphine itself would show significant relations only if the anhydrous form of the latter were available; but on comparison with anhydrous codeine, the monomethyl derivative, it is seen that all three axes of the acetyl compound are about 10 per cent longer than those of the methyl derivative, showing that the acetyl groups produce their greatest increase in direction *a*, but at the same time expand the structure somewhat in both of the other directions. It is thus possible by this method to throw some light on the positions of the chemical molecules in the crystals of these substances.

GEOLOGY.—*Present tendencies in geology: Sedimentation.*[1] EUGENE WESLEY SHAW, U. S. Geological Survey.

Interest in sedimentation has both direct and indirect practical bearing. The economic value of this interest may lie for the most part in the future, but should nevertheless be definite and certain. We wish to know how geologic strata were formed. The more we learn about processes and their results the more we find there is to learn, and the more the field widens and apparent complexity increases the more fascinating becomes the subject.

The main needs felt are (1) a better understanding of the deposits of past ages; (2) a wider knowledge and better understanding of the processes now in operation and of their results, as seen in the distribution of sediments, and the form of depositional surfaces—submarine, sublacustrine, subfluvial, subaerial, and subglacial; (3) the ability to apply our knowledge to economic problems the solution of which may rest on the nature of ancient strata and the processes of their deposition, or on similar data concerning present-day deposits. It can be demonstrated that knowledge of sedimentation may reduce the costs of finding the mineral treasure of the sedimentary basins, of harbor improvement, of fish culture, etc.

A knowledge of sedimentation involves a study of the processes and immediate results of deposition; the source of sediment and

[1] Presented before the Geological Society of Washington, May 28, 1919.

its transportation; and the processes which modify strata and their component materials after they are laid down. The term sedimentation should cover these related matters, else another term is needed, for it seems impracticable to isolate these three branches of investigation.

The interpretation of a layer of sediment may involve the examination of the parent rocks or organisms or solutions from which it was derived and a study of the transporting agents that brought it to its present position. It may be possible occasionally to trace ancestry back through several generations of strata but the numbers of individuals in each preceding generation usually show an increase more rapid than the usual biologic ratio of 2, and one is soon lost in a maze which generally obstructs attempts to trace lineage back to the ancestral igneous and metamorphic rocks.

It is rather curious that although the problems of sedimentation are relatively simple, advances in the science, in the opinion of some, have been of a slow and halting nature. The temperatures and pressures involved in processes of sedimentation are of a low order compared with those concerned in the study of igneous rocks. One or more of the processes are everywhere in operation; many of them can be reproduced in large part, some with simple apparatus; and the deposits themselves are fully exposed to view and ready for inspection and sampling.

Apparently there have been and will continue to be two general ways of making progress in knowledge of sediments: One is through contributions from geologists in general and paleontologists in particular, who gather facts and formulate ideas in the course of their other work. For example, A. C. Veatch observed impressions of upright trees and, with the associated stratification, interpreted a formation as made up of sand dunes. Stephenson suggests that pebbles worn to disc or oval shapes indicate wave action on a beach. Ulrich has outlined the general conditions of deposition of various formations. The other method is by special deductive or inductive field, laboratory or closet studies of selected sediment problems. Up to date there have been many contributions to the first class; to the second, few.

Notwithstanding the fact that advances have been made, there is as yet no adequate systematic classification that is generally acceptable. There is not even a satisfactory nomenclature.

There are many features of sedimentary deposits that are not understood and are passed unexplained. Concretions, clay balls, mud pebbles, quicksand, singing sand and a large number of less common nameless features are familiar but not thoroughly understood. There are also, for example, extremely interesting problems concerning the development of beaches, the conditions that control the amount of wave erosion which a subsiding land undergoes, and so on. One may assume that wave erosion is most vigorous at the seaward end of a peninsula that is bordered by deep water. Yet the offshore slopes both at the south end of the Florida peninsula and off the mouths of the Mississippi are above average, whereas wave erosion is below the average. At the mouths of the Mississippi the average offshore slope is about 60 feet to the mile, yet houses built on piles whose tops are 4 to 6 feet above sea level are reasonably safe even in a West Indian hurricane.

Progress in deciphering the processes of sedimentation is difficult; the quantity of data and number of working hypotheses to be borne in mind are legion. Lack of progress has been due not only to neglect and oversight but to inherent difficulties. A review of a piece of work in sedimentation is likely to call forth the remark, "Fundamental problems are still unsolved." Too much must not be expected from little expenditure of energy. It is equally true that coordination of effort is necessary for the best results.

We must admit that we can see only dimly the conditions under which many of our most familiar formations were laid down. We cannot yet write the equation for the reaction which in Nature's laboratory produced the St. Peter sandstone. We can, of course, write: a supply of sufficiently coarse-grained material exposed at the surface + suitable agents operating in the right direction for its transportation + land of suitable surface configuration and altitude + disposal by some means of all other freight carried by these agents + wind or some other work to

round and frost the grains + a transgressing sea to redistribute the sand without introducing any more mud than the formation contains, and so on; but at the end we would still have a very poor idea of the conditions of deposition. Indeed if each known element in the equation were fully understood and were reproduced we probably should not get another St. Peter sandstone, and possibly the result would only remotely resemble it.

The Devonian black shale, the great coal beds with their persistent thin partings, the wide-spread sandstones, such as the Dakota and Berea, the oolites, the so-called "Lafayette formation," and a great many others are still more or less matters of mystery. We are inclined to make remarks of satisfaction such as that we were formerly misguided regarding a certain formation but that we know better now,—we understand the conditions of its deposition; we used to think, for example, that coal is a product of tropical climate; now we know that it is formed under temperate or cool temperate conditions. But is there not still a great gulf between the relatively small and rarely smothered peat bogs upon which our assumed understanding of coal rests and those great expanses of peat swamp which developed over a sinking and frequently flooded land?

It seems to me that after all, we know for most strata only the main features of their conditions of deposition. We do not know whether the surficial sand and gravel deposits of the Atlantic Coastal Plain are mainly marine or mainly fluviatile, and this, notwithstanding the fact that all are geologically recent and some very recent formations. Various criteria become obscure with age and in particular the related physiographic features are gradually wiped out. Yet here in spite of youth and more or less perfect preservation of several kinds of physiographic features we are still groping in the dark, and are fortunate if we are able to avoid the pitfall of jumping at conclusions.

Vaughan[2] says: "It is generally agreed that the soundest basis for inferring the condition under which past sediments were formed and deposited is to be obtained through a study of pres-

[2] Unpublished memorandum to National Research Council.

ent-day sediments and sedimentary processes and that as great a diversity of phenomena as possible should be investigated." In the report of the Petrologists' Club committee on sedimentary rocks[3] it is stated that "The main object of petrologic descriptions of sedimentary rocks is evidently the interpretation of sedimentary records, though such descriptions should be useful also for identification, classification, economic purposes, and miscellaneous reference."

The need of carefully recorded descriptions of the physical characteristics of ancient sediments is especially worthy of emphasis. We have as yet no adequate color scale and statements concerning texture are usually only the crudest approximations. In geologic field work the proportions of various sizes of grains are rarely determined. The term "porosity" is used promiscuously for "total volume of pores," for "size of pores" and for "perviousness"—entirely distinct concepts. Mineralogic or chemical constitution is rarely determined in detail;—our classic table of average chemical composition of sedimentary rocks is, I believe, defective;[4] and shape of grains in noted only occasionally.

Methods of collecting specimens are much in need of standardization. Many samples represent a considerable thickness of strata—from a few inches to a foot or more,—within which more or less difference in conditions of deposition may occur. The resulting complexity in the sample greatly reduces the value of any mechanical analysis.

Though already recognized, the fact is still worth pondering that the bulk of our knowledge of sedimentation has come more or less inductively from the study of sedimentary rocks, conditions of deposition being inferred from general principles of physics and chemistry. Studies of present-day agents, processes, and kinds of deposits would furnish a much better foundation, though admittedly such studies would not be complete, because the conditions of deposition of most strata, particularly as to areal extent and also in other respects, are not fully represented anywhere at present.

[3] Mimeographed report signed by M. I. GOLDMAN, D. F. HEWETT, G. S. ROGERS, and E. W. SHAW.

[4] SHAW, E. W., *Sulphur in rocks and in river waters.* THIS JOURNAL 5: 484. 1915.

We sometimes feel that the general arrangement and distribution of deposits on lake and sea floors is fairly well known, yet the only detailed areal survey of any considerable portion of the sea floor—that made by Thoulet in the Gulf of Lyons—leads to a map that no physiographer or stratigrapher could have produced in advance.

Accurate surveys of selected areas of ocean and lake floor are greatly needed; areas not far off shore are of especial interest because of their economic bearing and because here there is greatest variety in process and nature of deposit. Contributions of this sort have already been made by Kindle for certain of the Great Lakes and by Vaughan for waters off the coast of Florida. Inductive work along the same line has been done by many geologists, among the foremost of whom is that eminent geologist of Lehigh and Yale whose loss we are now feeling so keenly. Experimental work has been done by a few, the most noteworthy being perhaps that of Gilbert[5] and Engels.[6]

Not only is there need of increase in the knowledge of sediments but there is need of dissemination of the knowledge heretofore gained. Some of the discoveries already made are not serving as they might. It has been shown that corals contribute little to accumulation of sediments and yet some still speak of coral islands and coral limestone in a way that indicates a misconception. We speak of clastic, chemical, and organic deposits, forgetting that limestones are generally clastic: are composed of fragments, now more or less extensively recrystallized, that were transported on the average thousands if not tens of thousands of feet. We interpret a great many sand lenses as fossil beaches, forgetting that shore deposits are as a rule ephemeral.

Although the study of sediments has lagged behind other branches of geology, real progress has been made in a number of problems. It is worthy of note that most of this progress has been made by men engaged primarily in other lines of science, by men

[5] GILBERT, G. K. *The transportation of debris by running water.* U. S. Geol. Survey, Prof. Paper 86. 1914.

[6] ENGELS, H. *Fluss-Strecken mit beweglicher Sohle.* Zeits. für Bauwesen. 1905.

who have either made valuable observations in connection with other work or who have dropped their other work for a time while they undertook a special study of sediments.

Especially noteworthy advances in the study of present-day sediments have been made during the last decade or two. Murray and others have collected much information concerning the great ocean deeps. Thoulet gave us a detailed map showing the areal distribution of sediment over a portion of the sea floor. Engels experimenting with an artificial stream analyzed processes of alluviation. Gilbert deduced, from a series of experiments, certain fundamental laws concerning fluviatile transportation of sand and gravel.

Barrell gave us a philosophical discussion of the conditions and processes involved in the accumulation of littoral deposits. Kindle has observed and recorded diagnostic features of various kinds of deposits. Udden has presented the results of many years of study of the mechanical constitution and peculiarities of the main classes of sediments. Goldman has given us the results of his investigations of sources of certain sediments and the diagenesis of others.

Recently T. W. Vaughan has put into operation a plan for coordinating the energies of those principally interested in sediments, and in response to his request they have submitted memoranda which have been transmitted to the National Research Council. The main feeling behind the movement is expressed in Vaughan's memorandum in the following words: "As the factors entering into both the origin and deposition of sediments are so diverse and so widely distributed it is impracticable for any one man, any small group of men, or any organization whose activities are really limited to cover the field."

Some quotations from the replies will be of interest. Barrell, obviously impelled mainly by his interest in earth history, says by way of introduction to his "*Project for a study of sedimentation*," dated January, 1919:

"If the interpretation of the climatic and physiographic history of the earth, as based on the nature of the sedimentary rocks, is to progress along lines now opened up, it is neces-

sary that comprehensive systematic studies of modern sedimentation be undertaken from this interpretative standpoint. Such men as Lyell and De la Beche made a good beginning, but the present problems of earth history were beyond their horizon, and the older studies of sedimentation were, furthermore, general in character and descriptive of the thing in itself rather than of its significance. The idea of the necessity for criteria for the discrimination of various climatic and physiographic controls in the making of ancient sediments was until recently a point of view not conceived."

Blackwelder says that because of his interest in the earth's physical history and his experience with sedimentary rocks he has been "especially impressed with the advantages to be gained from painstaking study of the consolidated formations" and in particular their lateral variations. He suggests "the exhaustive study of individual types or type groups of sediments in both modern and lithified state."

Kindle is especially interested in lake and sea bottom deposits, in ripple marks, in migration of shores and transportation of littoral deposits, etc. Steiger and Wells present an outline of needed and practicable chemical and physico-chemical work. Others have contributed valuable suggestions.

SUMMARY

Although to progress in the understanding of sediments is somewhat difficult the need is real. Much can be accomplished through coordination, through getting geologists of all lines to give some attention to the subject, and through carefully considered and well executed special plans. Apparently the trend of thought at the present time is in harmony with the needs. Some assistance has already been rendered and more is planned by specialists in other lines. Physicists, chemists, biologists, and others are ready to study marine deposition, the bottom loads of rivers, cementation, dolomitization, problems connected with the origin and accumulation of petroleum, and the geophysics and geochemistry of the great sedimentary basins. Physiographers and climatologists will make their contributions.

It is hoped that a sediment laboratory may be equipped and operated in the Geological Survey. In this laboratory many kinds of petrologic investigation should be carried on. Mechanical analyses of specimens of various present-day and ancient deposits and studies of mineralogy, porosity, specific gravity, and shape of grain will be undertaken. It is hoped also that a useful collection of sediments and sedimentary rocks may be built up, as was planned by Hayes, Lindgren and others. The work should be pushed without extravagance but with vigor.

What contributions we may expect from field work on sediments now in process of accumulation is not definitely known, but no doubt studies will be made of certain such deposits. In the Florida Keys, for example, this may involve continued research on the composition of sea water and the questions of whether or not this water is saturated with carbonate of lime and whether cementation of the shell and other fragments may take place below sea level.

During the last decade there has, I believe, been some increase of interest in the study of sediments. Although during the war investigations were checked, there is at the present time, I hope, and am inclined to believe, an increasing interest in the science and a tendency toward cooperation which will lead to fruitful investigations.

ANTHROPOLOGY.—*Some general notes on the Fox Indians. Part II: Phonetics, folklore and mythology.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

FOX PHONETICS

I have elsewhere[2] briefly discussed the chief differences between Jones' scheme of Fox phonetics and my own. There are a few points that should be taken up here. The most important one is that before an initial consonant of a following word a terminal voiceless aspirated vowel of the preceding word becomes full-sounding and loses its aspiration. As terminal voiceless aspirated vowels are normally lost before initial vowels and diphthongs,

[1] Published with the permission of the Secretary of the Smithsonian Institution.
[2] Internat. Journ. Amer. Ling. 1: 54.

it will be seen that they are strictly only proper when a break in sense occurs. Unfortunately it was not possible to teach informants to dictate the words this way. It depended on the length of words as to whether I could take more than one at a time; and in this way the resulting texts contain mixed sentence-phonetics. The choice therefore remains of printing texts with these inconsistencies or making the phonetics uniform. It seems correct to do the latter so far as sentence-phonetics are concerned. In this normalization I have chosen the full-sounding terminal vowels before initial consonants, save where the sense indicates a pause; before initial vowels and diphthongs terminal voiceless aspirated vowels are eliminated. In this matter I have been guided not only by the fact that in this way a truer picture of the language is presented, but also because in so doing complicated symbols are avoided: thus -$m^{mA'}$ is eliminated in favor of -mA and -m, and so on. The elimination of terminal voiceless aspirated vowels before initial vowels and diphthongs is to a certain extent at least a question of tempo; in actual Fox speech I have heard them even as full-sounding in this position. The texts accordingly represent allegro tempo. Even final full-sounding vowels are aspirated before an initial sibilant. Another point may properly be brought up. Within verbal complexes the elision of final i of one morphological element before another such element beginning with a vowel or diphthong, especially in "loose composition," is to a certain extent a matter of allegro or lento tempo. I have followed the usage of the reciter of the texts. It may be noted that in the current syllabary the Foxes are not consistent in writing or omitting such a vowel; yet in "loose composition" the vowel is written for the most part, and elided in intimate compounds. It should be remarked that the Meskwakis themselves in such cases very frequently separate the elements by periods. The principal word accent is indicated by the acute (′). Following the recommendations of the committee of the American Anthropological Association[3] I have employed the symbols and

[3] *Phonetic transcription of Indian Languages*, Smiths. Misc. Coll. **66**, No. 6: 1.

general scheme of Dr. Jones in the matter of things phonetic save where in my judgment they are inadequate.

The following table will show the phonetic elements of Fox as I conceive them:—

Vowels and diphthong

Full-sounding:

a A *e* *i* *o* *u*
ā *â* *ā* *ē* *ī* *ō*[1]

(*ē* never occurs save terminally as a rhetorical lengthening of *e* or *i*, and then has an *i*-vanish; *ō* when a terminal rhetorical lengthening similarly has a *u*-vanish; *â* is found only after *w*).

ai (only before *y*),

an (only in the exclamation *'au'*).

Voiceless and aspirated (terminally only):

A' *a'* *e'* *i'* *o'*

Consonants

	Stops	Spirants	Affricatives	Nasals	Semi-vowels
Glottal	'		..	..	..
Palatal	*k* 'k *g* g^k	..	..	..	y^y
Alveolar	..	*c* 'c	*tc* 'tc ^{d}*tc*	..	..
Dental	*t* 't *d*	*s* 's	..	n^n	..
Labial	*p* 'p *b*	..	..	m^m	w^w

The sibilants *s* and *c* occur only initially; otherwise they are replaced by *'s* and *'c*, respectively. The spirant *c* after back vowels is nearly intermediate in effect between a surd velar spirant and our *h;* after front vowels the effect is more palatal. It always occurs before initial vowels and *ai*. The stops *g d b* are articulated with greater strength than in English; they never occur initially; before terminally voiceless vowels *g* becomes g^k; *d* and *b* (both of which are rare, especially the former) do not occur in final syllables. Voiceless ^{n} ^{m} ^{y} ^{w} are phonetic modifications of *n m y w*, respectively, before terminal voiceless vowels. The affricative ^{d}*tc* occurs initially and medially save in final syllables; ^{d}*tc* occurs mostly in final syllables, though also in medial ones. It may be noted that *'k 't 'p 'tc* are given as a series, because (outside of verbal compounds after *'ā-, nī-, kī-, wī-* where they are transformations of *k t p tc*) they correspond in Cree to a sibilant followed by *k t p tc*. It may be added that

[1] *ā e i u* are open; *ī ō* are close.

'p 't and *'tc* never occur in terminal syllables nor initially. The surd *k t p tc* are unaspirated; *k p tc* never occur in terminal syllables.

To forestall hasty criticism it should be said that the differences in the quantity and quality of the vowels in such words as *'ī'wᴬ'* "he said," *'ā'i'ᵈtci'* "then he said;" *'ugimā'ʷᴬ'* "chief," *'utōgimāmwāwᴀn i'* "their chief;" *pemipa'ō'ʷᴬ'* "he runs by," *pemipa'owᴀgᵏⁱ'* "they run by," *nepemipa'ᵘ'* "I run by," *'ā'pemi'pa'uᵈtc i'* "when he ran by;" *nenī'ʷᴬ'* "man," *ne'niwᴀnⁿⁱ'* (obviative of the same), *neniwᴀ'gᵏⁱ'* "men;" *ne'sᴀnᴀgi'ᵘ'* "I had difficulty with it," *sᴀnᴀge'sī'ʷᴬ'* "he is incorrigible" are true phonetic processes and are not merely due to mishearings.[5] I have had abundant opportunity to test these again and again to be sure that there was no error in apperception; and Mr. J. P. Harrington (of the Bureau of American Ethnology) also agrees that these differences are truly phonetic and not merely auditory. The phonetic laws governing these shifts have not been determined, but it is clear that the position of the accent and the nature of the adjacent sounds are in a large measure responsible for the phenomena. The influence of the last are responsible for the different results seen in the contractions[6] in *nekī'ci'tā'gᵏʷᴬ'* "he made it for me," *kekī'ci'tō'nᵉ'* "I made it for thee" as compared with *kekī'ci'ta'wipenᵉᵃ'* "you made it for us," *kī'ci'tawā'ʷᴬ'* " he made it for him." It is in the belief that some time it may be possible to enunciate phonetic shifts with accuracy that certain apparent fluctuations have been allowed to stand. Thus for example the fact that *â* never occurs except after *w*, and never in penultimate syllables suggests that it is a modification of *ā* due to the influence of the neighboring sounds, including following ones. The fact that *a* never occurs in penultimate syllables though both *ā* and ᴀ do,[7] tends to show a phonetic shift or shifts have taken place. Hence it is well to be conservative in holding that cases where *a* and ᴀ

[5] This will be shown in a future number of the *International Journal of American Linguistics*.

[6] See this JOURNAL, 9: 333.

[7] Neither does it occur before *'k, 't, 'p, 'tc, 's, 'c*. Where Jones records *a* in such cases I hear ᴀ. Similarly I hear ᴀ for *a*, and *ᴬ'* for *ᵃ*.

apparently interchange medially are merely mishearings. The limitations of the positions of certain consonants (see above) likely enough are in part due to phonetic shifts; some are certainly due to these. The evidence of cognate dialects favors the view, but this is not the proper place to discuss this aspect in detail. In conclusion it may be noted that *ck*, *'ck* are the only true consonantal clusters in the language. The cluster *st* is found in English loan-word *'i'stakinA'n^{ni}* "stockings."[8] According to William Jones *stc* occurs in an exclamation.

FOX FOLKLORE AND MYTHOLOGY

The time for a final discussion of Fox folklore and mythology is hardly ripe. For comparative purposes the data are too meager. We are practically without any Sauk material; the Kickapoo published (Jones) and unpublished (Michelson) collections are inadequate; the published Potawatomi material is negligible, and that unpublished (Skinner, Michelson) is probably insufficient; the unpublished[9] material of Peoria folklore and mythology (Gatschet, Michelson) is adequate; the published Cree, Algonkin, and Ottawa collections are deficient; the published Menominee material is adequate; the published and unpublished (Jones) material of Ojibwa folklore and mythology is extremely extensive; and so is that of Fox, especially the unpublished portion (Michelson). So that even a comparative study of the folklore and mythology of only Central Algonkins would be very one-sided. When the inadequate published data from such Siouan tribes as the Iowa, Winnebago, and Osage are taken into account, it will be seen that a truly comprehensive study of Fox folklore and mythology is, for the present, quite out of the question. Happily there is plenty of unpublished Winnebago material (Radin), and possibly Iowa (Skinner), so that in the near future conditions may be distinctly improved. At the present time the only adequate collections of Siouan folklore and mythology are from the Assiniboine, Crow, and Omaha; the published material of the Sioux proper is insufficient.

[8] Also in a couple of other loan-words.

[9] See now MICHELSON, Journ. Amer. Folk-Lore 30: 493–495.

The late Professor Chamberlain[10] undertook a brief comparative study of the myth of the culture-hero among Central Algonquian tribes, but the Sauk and Fox material available at that time seems to have escaped him; and it must be said in justice to him that it was not readily accessible. The paper by the late J. Owen Dorsey,[11] should be read in connection with Professor Chamberlain's article. Some years later Professor Dixon[12] published a comparative study of the mythology of Central and Eastern Algonkins. As he was able to use the Fox collections of Jones, his paper is of importance to us. Unfortunately his sources are not given, nor are the mythologies of the plains Indians used in his study. Nevertheless this article is very useful as a stepping-stone. The essential points which Dixon seeks to establish as regards Fox folklore and mythology are: (1) Fox has one set of non-culture-hero incidents with Menominee, and another with Cree-Ojibwa; (2) Fox shares with Ojibwa but few such incidents in common with the Eastern group, though both, especially Ojibwa, have a number of such incidents with this group; (3) Fox has a number of elements which are typically Iroquoian; (4) Fox and Potawatomi form a special group among the Central Algonquian tribes. Additional material, published and unpublished, since 1909, shows that these theses will have to be somewhat modified. I have gone over Barbeau's *Huron and Wyandot Mythology* and find that with one possible exception Fox has not a single incident in common with Huron-Wyandot which is not shared with some other Central Algonquian tribe. And my unpublished Potawatomi material, which, though inadequate, is far greater in extent than that published, tends to show that the fourth thesis is wrong. Fox folklore and mythology is treated but incidentally by Dr. Radin in his *Literary aspects of North American mythology*, but it should be stated that on page 8 he has confused the Fox and Menominee versions of the cycle of the death of the culture-hero's younger brother. The general subject of the

[10] Journ. Amer. Folklore 4: 193–213.
[11] Ibidem 5: 293–304, *"Nanibozhu in Siouan Mythology."*
[12] Ibidem 22: 1–9 [Jan.–March, 1909].

mythology and folk tales of North American Indians is treated by Boas.[13]

I have spoken above of my unpublished collection of Fox folklore and mythology. This consists of several thousand manuscript pages written out by Indians themselves. It should be mentioned that even the stories previously published by Jones have an entirely distinct literary style in this collection. I presume this is due to the difference in the method of collecting the material. However, it must not be assumed that all my Fox myths and tales are of a single style. Indeed, on the basis of style alone it would be possible to refer many to their respective authors. For example, informant A is extremely prolix, and fond of detail; informant B is brief, but lugs in the rolling-skull episode on every possible occasion; informant A is a skillful narrator and the tale runs along smoothly and with artistic effect; informant C is unusually awkward; though his tale may contain every incident in the corresponding story of informant A, nevertheless there are distinct breaks in the narrative, and so his tale could not be printed without patching up these portions, however valuable it might be for linguistic purposes or for a control of the myths and tales of others. A question I hope to take up at a future date is the choice of words and phrases among different informants.

As to the contents of the above collection. A large percentage of the myths and tales in Jones' Fox Texts has been duplicated; almost all of these occur with rather greater detail than in his collection; numerous other myths and tales, among them the Cosmic Myth, about 1,200 manuscript pages, of the type represented in his collection naturally have also been collected: the distinguishing features of my collection are the more numerous animal tales; many stories clearly of European origin; origin-legends of gentes; ritualistic origin-myths. I have previously pointed out some of the European cycles.[14] To these may be added a fox cycle of considerable length and another called "Tiger;" and it may be noted that Cosmic Myth (the story of Me'sA'kAmigō'kwäw^{A}') has an enormous number of incidents

[13] Journ. Amer. Folklore 27: 374–410.

[14] Amer. Anthrop., n. ser. 15: 699.

that are patently European. The French-Canadian collections by Barbeau in the *Journal of American Folklore* make it probable that Cā'kanā'ᴬ' is not a corruption of Jacques le but rather of Jacquelin. Skinner's statement[15] that "the Central Algonkin as a whole have not absorbed much folklore that is European" is not justified by the facts of Fox or Peoria tales. I have made a brief study of Fox ritualistic origin myths.[16] The essential point is that thus far this particular type of ritualistic origin myths is unique owing to the profusion of information contained in them. The value of these myths for strictly ethnological studies has also been emphasized.

As said above, the time is not yet ripe for a final discussion of Fox folklore and mythology. Nevertheless an opinion based on the present materials may be of some value. Disregarding the origin-legends of gentes and ritualistic origin-myths[17] for the lack of comparative material, it is clear that Fox folklore and mythology is composed of woodland, plains, and European elements.[18] The plains elements are firmly established by the distribution of the tales corresponding to the Fox story of how the culture-hero (WĪ'SA'KÄ'A') rolls himself downhill to catch turkeys, and the tale of his eating the artichoke; correspondents to the former occur among the Skidi Pawnee, Caddo, Biloxi, Alibamu, and Ojibwa (ducks secondarily); to the latter among the Menominee, Eastern Dakota, Assiniboine, Crow, Pawnee, Skidi Pawnee, Arikara, and Wichita. The occurrence of correspondents to the Fox story of the beaver and culture-hero among the Peoria, Ponca, and Shoshoni also points to the plains as a center of distribution. If I have emphasized the occurrence of plains-elements in Fox folklore and mythology, it is because hitherto the stress has been on the woodland-elements. From the materials available it would seem as if Kickapoo folklore and mythology on the whole are closest to those of Fox, and that Ojibwa folklore and mythology are rather remotely connected therewith.

[15] Journ. Amer. Folklore 27: 100.

[16] This JOURNAL 6: 209–211. 1916.

[17] The native term for such as refer to the festivals of the gentes is *kīgänowi'äte' sō'kägᴀnᴮᴬ'* (plural -ᴀʜᴀg$^{ki'}$).

[18] Compare Amer. Anthrop., n. ser. 15: 699.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Oxidized zinc ores of Leadville, Colo.* G. F. LOUGHLIN. U. S. Geological Survey Bulletin No. **681**. Pp. 91, pls. 8, figs. 7. 1918.

Although deposits of oxidized zinc ores at Leadville, Colo., had been exposed in mine workings for many years previously, it was not until 1910 that their character and extent began to be realized. Since that year large quantities have been mined annually. Bulletin 681 begins with a review of early accounts of zinc carbonate and silicate and of the recent discovery of the ore bodies. It then describes in detail the oxidized zinc ore minerals and minerals associated with them, the varieties of ore, their range in metal content, their distribution and extent, and their genesis. G. F. L.

GEOLOGY.—*The evaporation and concentration of waters associated with petroleum and natural gas.* R. VAN A. MILLS and R. C. WELLS. U. S. Geological Survey Bulletin No. **693**. Pp. 104, pls. 4, figs 5. 1919.

The widely observed association of saline waters with petroleum and natural gas is ascribed by the authors, at least in many cases, to deep-seated concentration brought about by evaporation into moving and expanding gas. During this concentration there is a definite order of change in the relative proportions of the dissolved constituents in the waters. Carbon dioxide and other gases are lost from solution. Calcium, magnesium, and iron separate from solution as carbonates, and, under favorable conditions, sodium chloride separates,—a process illustrated in the "salting up" of gas wells.

In discussing these changes the authors present evidence based on field studies as well as laboratory determinations, including the results of examinations of the rock specimens, analyses of the waters, the determination of the solubility of salt in solutions carrying calcium chloride, the vapor pressure of water in illuminating gas, and a résumé of the initial gas pressures in several gas fields. Elaborate compar-

isons are also given between the deep-seated Appalachian brines, sea water, and surface waters, intended to show the probable changes that have taken place in the oil and gas field waters. In short, the complete history of the waters is sketched, as nearly as it is possible to do so, from the time of their inclusion in the sediments to the present. Effects likely to be caused by changes in temperature and pressure such as it is reasonable to suppose may have affected the strata are pointed out.

Some practical applications of the principles and discussion are given. It is suggested that analyses of the waters in or near oil and gas fields may throw light not only on the location of the more valuable fluids, but also on the probable reactions and precipitations that might ensue when the different waters are allowed to mix either in the wells or in the strata. Careful consideration should also be given to the movements and rearrangements that the oil, gas, and water undergo incident to extraction. R. C. W.

GEOLOGY.—*Relations of Late Paleozoic and Early Mesozoic formations of southwestern Montana and adjacent parts of Wyoming.* D. DALE CONDIT. U. S. Geol. Survey Prof. Paper 120-F. 1918. Pp. 111–121, pls. 5, fig. 1.

This paper presents evidence found in southwestern Montana concerning the great Jurassic base-leveling and its bearing on the solution of certain stratigraphic problems involving late Paleozoic, Triassic, and Jurassic formations, and sets forth the relations of those formations to beds in western Wyoming. The conclusions briefly summarized are as follows:

Prior to the encroachment of the sea from the northwest in late Jurassic time prolonged erosion and base-leveling occurred over much of the Rocky Mountain region. From Idaho State line near Yellowstone National Park northward to the vicinity of Helena the erosion surface thus produced truncates beds of Triassic and Carboniferous age, through a stratigraphic range of about 1,000 feet.

The Quadrant quartzite at the type locality in the northwestern part of Yellowstone Park is approximately equivalent to the Amsden and Tensleep formations in Wyoming. The Park City (Pennsylvanian and Permian), Dinwoody (Lower Triassic), and Chugwater (largely Triassic) of the Wyoming section are in part represented by the Teton formation of Yellowstone Park. The quartzitic cherty basal beds of the Teton, containing the phosphate rock, are equivalent to the Phos-

phoria formation of Idaho, which corresponds to the upper part of the Park City formation. In western Montana north of latitude 45° 30′ the overlying Triassic shaly limestone and red shale were removed by the Jurassic erosion and the Ellis formation (Upper Jurassic) rests on the partly eroded Phosphoria formation. R. W. STONE.

GEOLOGY.—*Geology of northeastern Montana.* ARTHUR J. COLLIER. U. S. Geol. Survey Prof. Paper **120-B.** Pp. 17–39, pls. 6, figs. 5. 1918.

Describes a large thinly settled region in northeast Montana which is part of the Great Plains. The topography is discussed and formations from Cambrian to Jurassic exposed in Little Rocky Mountains are described briefly. The Cretaceous, Tertiary, and Quaternary formations are described more fully, and the geologic structure is explained. Drainage diversion due to the invasion of ice during the glacial epoch forms an interesting conclusion of the report. R. W. STONE.

GEOLOGY.—*A contribution to the geology of northeastern Texas and southern Oklahoma.* LLOYD WILLIAM STEPHENSON. U. S. Geol. Survey Prof. Paper **120-H.** Pp. 129–163, pls. 14. 1918.

This paper sets forth the present state of knowledge in the areal mapping, in the interpretation of structure, and in correlation, and indicates certain mappable units and structural features that have not heretofore been recognized in the region in central and northeastern Texas and southern Oklahoma known as the Black and Grand prairies. The area lies near the northwestern border of the Gulf Coastal Plain in northeastern Texas and southern Oklahoma, and is a dissected coastal-plain upland ranging in altitude from about 530 feet in the southeast to 850 feet in places in the northwest. The drainageways of the area present many good examples of consequent, subsequent, obsequent and perhaps other classes of streams.

The area is underlain throughout its extent by strata of Cretaceous age, which rest upon a buried, moderately smooth basement composed of ancient rocks. The tilted peneplained surface of the basement rocks dips to the south from the northern boundary at rates estimated to range in different places from 50 to 70 feet or more to the mile, and to the southeast from the western boundary at rates probably ranging from 40 to 50 feet to the mile.

The basement rocks are separated from the overlying Cretaceous deposits by an unconformity representing a long interval of geologic time, including at least the Triassic and Jurassic periods and probably a considerable part of the Lower Cretaceous epoch.

The Cretaceous deposits are divisible into two great series, a lower, the Comanche series, which appears at the surface about the flanks of the Preston anticline in the northwestern part of the area and has an estimated thickness of 800 to 1,000 feet, and an upper, the Gulf series, which has an estimated thickness of at least 3,000 feet and the outcrop of which covers considerably more than half the area. Each of these series is separable into subordinate divisions. The Gulf series is unconformably overlain by strata of Eocene age which appear at the southeast in a relatively small part of the area. In general the strike of the strata is parallel to the inner margin of the Coastal Plain, and the dip is coastward from this margin at rates ranging from 30 feet or less to 80 feet or more to the mile. A considerable departure from the prevailing regularity in strike and dip occurs in the northwestern and central parts of the area, in connection with the Preston anticline.

The Cretaceous deposits consist of sand, shaly clay, calcareous shaly clay, limestone, and chalk. Pleistocene alluvial terrace deposits largely conceal the Cretaceous formations in a broad area.

R. W. STONE.

GEOLOGY.—*Geology and ore deposits of the Yerington district, Nevada.* ADOLPH KNOPF. U. S. Geol. Survey Prof. Paper 114. Pp. 68, pls. 5, figs. 12. 1918.

The Yerington district in western Nevada is, next to Ely, the most productive copper district in the State. The oldest rocks of the district consist of andesites, keratophyres, and limestone, with subordinate shale, quartzite, and gypsum, all of Triassic age. They were intruded in post-Triassic time, probably early in the Cretaceous, by granodiorite, which was followed by quartz monzonite. These intrusions intensely metamorphosed the rocks they invaded and converted large areas of them into lime-silicate rocks. After this metamorphism the region was cut by numerous dikes of quartz monzonite porphyry. Faulting then ensued, and along the faults ore-forming solutions rose and produced the copper deposits to which the district owes its economic importance.

The Tertiary rocks, resting with marked unconformity on the Mesozoic group, are chiefly volcanic and are at least 7,000 feet thick. They fall into three major groups which are separated by two well-marked unconformities. The lowest subdivision consists of quartz latite, rhyolite, and andesite breccia; and it is probably the correlative of the Esmeralda formation of Upper Miocene age. The middle subdi-

vision consists of andesite flows resting in places on the eroded edges of the rhyolites. The uppermost subdivision consists of subangular conglomerate overlain by basalt.

The principal ore bodies consist of pyrite and chalcopyrite in a gangue of pyroxene, garnet, and epidote. They are replacement deposits of limestone developed along fault zones and are of the contact-metamorphic type. The primary ore is essentially unenriched by later sulphides. The average tenor of the ore mined has ranged from 2.75 to 6 per cent of copper. A. K.

ANTHROPOLOGY.—*The Maya Indians of southern Yucatan and northern British Honduras.* THOMAS W. F. GANN. Bull. Amer. Ethnol. 64. Pp. 146, pls. 28, text figs. 84. 1918.

The Maya Indians will always be noteworthy as those who attained the highest cultural development in America, or at least in North America. A study of the living representatives of that race or of their antiquities is therefore doubly welcome and in the present bulletin we have both; Part 1 being devoted to the "Customs, Ceremonies, and Mode of Life" of the modern Maya and Part 2 to "Mound Excavation in the Eastern Maya Area." The former, covering 36 pages, considers the habitat, personal characteristics—including the material culture—and the social characteristics—including religion; the latter contains a short description of the ancient inhabitants of the region as revealed by studies of the mounds and objects found in them, but the larger part of the section, and of the work itself, 84 pages, is devoted to the archeological remains themselves. J. R. SWANTON.

ZOOGEOGRAPHY.—*Life zone investigations in Wyoming.* MERRITT CARY. N. Amer. Fauna **42**: 1–95, pls. 15, figs. 17. 1918.

This bulletin embodies the results of many years' exploration in Wyoming by the author and other members of the Biological Survey. These investigations serve to emphasize the diversified character of the physiography of Wyoming. Its chief characteristics are its many mountain ranges, vast, open rolling plains, and deep-cut valleys due to the numerous streams. The climate of the State is mainly arid, the rainfall from 10 to 20 inches, with warm summers and cold winters. As a consequence of these physiographic conditions the life zones of the State show remarkable diversity. Of the seven trans-

continental life areas all but two occur in Wyoming; and their interrelationships are, as would be expected, greatly complicated. These five zones with a few of their characteristic species are as follows:

The Upper Austral Zone (represented here by its western arid subdivision, the Upper Sonoran), which occupies most of the valleys and lower plains, is the home of the broad-leaved cottonwood, juniper, salt bush and yucca; of such mammals as *Eutamias minimus pictus*, *Citellus tridecemlineatus parvus*, *Lepus californicus melanotis*, and of such breeding birds as *Zenaidura macroura marginella*, *Tyrannus vociferans*, *Passerina amoena*, and *Icteria virens longicauda*.

The Transition Zone, which embraces the high plains, the basal slopes of the mountains, and all the foot-hills except the highest, and covers fully half the State, is characterized by yellow pine, narrow-leaved cottonwood, and sage brush; such mammals as *Odocoileus virginianus macrourus*, *Sciurus hudsonicus dakotensis*, *Neotoma cinerea cinerea*, and *Lepus townsendi campanius;* and such breeding birds as *Centrocercus urophasianus*, *Cryptoglaux acadica acadica*, *Empidonax wrightii*, *Cyanocephalus cyanocephalus*, and *Hylocichla fusescens salicicola*.

The Canadian Zone, which covers the middle mountain slopes and the highest foot-hill ranges, is the boreal forest belt of spruce, fir, lodgepole pine, and aspen; and is furthermore delimited by such mammals as *Alces americanus shirasi*, *Glaucomys sabrinus bangsi*, *Phenacomys orophilus*, *Evotomys gapperi galei*, and *Lepus americanus americanus;* and such birds as *Charitonetta arbeola*, *Nuttallornis borealis*, *Melospiza lincolnii lincolnii*, and *Sitta canadensis*.

The Hudsonian Zone, which is a narrow belt covering the timber line region, is marked chiefly by the white-barked pine, dwarfed spruce and fir; together with such mammals as *Ovis canadensis canadensis*, *Eutamias oreocetes*, and *Ochotona uinta;* and such birds as *Nucifraga columbiana* and *Pinicola enucleator montana*.

The Arctic-Alpine Zone, which occupies the mountain crests and the portion of the peaks above timberline, is a treeless area, the vegetation of which is limited to low bushes and other humble plants like *Dryas octopetala* and *Poa arctica*, and is the home of such breeding birds as *Lagopus leucurus altipetens*, *Leucosticte australis*, *Leucosticte atrata*, and *Anthus spinoletta rubescens*.

Under each of these zones detailed lists of mammals, breeding birds, and plants are given, and a further list showing the distribution of all the conspicuous trees and shrubs of Wyoming which are of importance in delineating the life zones is also added.

HARRY C. OBERHOLSER.

SCIENTIFIC NOTES AND NEWS

MATTERS OF SCIENTIFIC INTEREST IN CONGRESS[1]

Mr. FESS has re-introduced his bill for a national university, which failed of final action in the Sixty-fifth Congress.[2] The present bill is H. R. 9353: "To create a national university at the seat of the Federal Government." The institution, to be known as the "National University of the United States," is to be governed by a board of trustees, consisting of the U. S. Commissioner of Education and twelve appointed members; the acts of the board are subject to approval by an advisory council, consisting of one representative (usually the president of the State University) from each State. No student is to be admitted unless he shall have obtained the degree of master of science or master of arts from an institution of recognized standing. No academic degrees are to be conferred. An initial appropriation of $500,000 is provided. The bill was referred to the Committee on Education.

A fact of interest to the scientific public is that the "Army reorganization bill" (S. 2715, Mr. WADSWORTH; and H. R. 8287, Mr. KAHN) makes no mention of the Chemical Warfare Service. In his letter accompanying the bill, Secretary of War BAKER suggests that the Chemical Warfare Service be made a part of the Engineer Corps. The proposal to abolish the Service as a distinct unit, comparable with the Tank Corps, is being vigorously opposed by the Council of the American Chemical Society.

Warnings issued by the Public Health Service in September that a recurrence of the 1918 pandemic of influenza was probable in the autumn months of 1919, stirred renewed interest in the various bills and resolutions providing for investigations of that disease, but no final action had been taken at the time of this report, although Mr. HARDING'S S. J. Res. '76 was reported in the Senate on October 1.

On September 3, Mr. MCKELLAR introduced S. 2920: "To enable the Secretary of Agriculture to carry out investigations of the causes and means of prevention of fires and dust explosions in industrial plants." The bill provides $100,000 for such investigations. Referred to the Committee on Agriculture and Forestry.

A plan for private development, under Federal concessions, of the platinum resources of Alaska is contained in H. R. 8988: "To incorporate the United States Platinum Corporation and to aid in the development of the mineral resources of Alaska, and for other purposes," introduced on September 3 by Mr. O'CONNELL (by request). The proposed Corporation would have a capital stock not to exceed $50,000,000; would be exempt from Federal taxation; would be empowered to receive concessions and leases of government-owned platinum sands in Alaska; would pay a royalty of one-eighth of its net products; and would furnish $100,000 for the maintenance of five "U. S. Government Commissioners of Platinum and its Allied Industries," whose duties are not defined in the bill. Referred to the Committee on Public Lands.

[1] Preceding report: This JOURNAL 9: 454. 1919.

[2] See This JOURNAL 8: 76. 1918.

No action was taken on the invitation of the French Government[1] to send delegates to a meteorological conference in Paris on September 30, and the United States was, therefore, not officially represented.

NOTES

The proposed American Meteorological Society, formal organization of which is suggested for action in connection with the next meeting of the American Association for the Advancement of Science, is expected to have a large Washington membership, drawn from the staff of the Weather Bureau and from among the meteorologists of the Army and Navy. It is suggested that the *Monthly Weather Review* be made the medium for publishing meteorological and climatological articles, while a monthly leaflet published by the Society would contain news, announcements, notes, and queries.

Mr. L. B. ALDRICH of the Astrophysical Observatory reports from the Smithsonian Station on Mt. Wilson, California, the successful operation of a new instrument for measuring the loss of heat of the earth to space at night.

Prof. ALFRED F. BARKER, Professor of Textile Industries at the University of Leeds, England, visited Washington in September to study the work being done in the Division of Textiles of the National Museum.

Dr. C. BONNE and his wife, Mrs. C. BONNE-WEPSTER, of Surinam (Dutch Guiana), students of South American mosquitoes, are spending two months at the National Museum in the study of the mosquito collection.

Mr. R. Y. FERNER, formerly with the Bureau of Standards, has resigned his position as assistant purchasing officer in the Emergency Fleet Corporation, where he had charge of the purchase of navigational outfits, and has opened an office in the Maryland Building, Washington, for the supplying of technical information and service to manufacturers and others.

Brig. Gen. CHARLES F. LEE, of the British Royal Air Force, who lectured before the Academy in March, 1918, on "Aviation and the War," was killed in an aeroplane accident in England on September 2.

Mr. PAUL C. STANDLEY, of the Division of Plants, U. S. National Museum, has returned from a collecting trip through Glacier National Park, Montana. Data were secured for a handbook of the plants of the Park, to be issued by the National Park Service for the use of tourists. About four thousand herbarium specimens were collected.

[1] This JOURNAL 9: 455. 1919.